01 Jan 1981

Phase 1 Inspection Report: National Dam Safety Program. Mississippi - Kaskaskia - St. Louis Basin. Lake Adelle Dam, Jefferson County, Missouri

Crawford, Murphy & Tilly, Inc., Springfield, Illinois

A & H Engineering Corporation, Carbondale, Illinois

MISSISSIPPI-KASKASKIA-ST.LOUIS RIVER BASIN

LAKE ADELLE DAM
JEFFERSON COUNTY, MISSOURI
MO 30411

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
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St. Louis District

D BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
TE OF MISSOURI

981

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Lake Adelle Dam Phase I Inspection Report
Jefferson County, Missouri
Missouri Inventory No. 30411

This report presents the results of field inspection and evaluation of the Lake Adelle Dam (MO 30411).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division

25 JUN 1981
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

29 JUN 1981
Date

MISSISSIPPI-KASKASKIA-ST. LOUIS RIVER BASIN

LAKE ADELLE DAM
JEFFERSON COUNTY, MISSOURI
MISSOURI INVENTORY NO. 30411

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Crawford, Murphy & Tilly, Inc., Springfield, Illinois
A & H Engineering Corporation, Carbondale, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

APRIL, 1981

PREFACE

This report is prepared under guidance contained in Department of the Army, Office of the Chief of Engineers, Recommended Guidelines For Safety Inspection Of Dams, for a Phase I investigation. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. Additional data or data furnished containing incorrect information could alter the findings of this report.

It is important to note that the condition of the dam depends on numerous and constantly changing internal and external conditions and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

PHASE I INSPECTION REPORT
NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS

Name Of Dam:	Lake Adelle Dam
State Located:	Missouri
Inventory Number:	MO 30411
County Located:	Jefferson County
Stream:	Unnamed Tributary to Skullbones Creek
Date of Inspection:	25 February 1981

BRIEF ASSESSMENT:

Lake Adelle Dam was inspected by a team of engineers from Crawford, Murphy & Tilly, Inc. of Springfield, Illinois and A & H Engineering Corporation of Carbondale, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers.

Lake Adelle Dam is an earthfill embankment constructed across an unnamed tributary to Skullbones Creek. The dam was constructed in about 1950. The dam is located in a residential subdivision and provides recreation and enhancement to the residents of the subdivision.

Based on the guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately one and a half miles downstream to the Big River. Located within this zone are a sewage lagoon, a dwelling, a small lake, Cedar Hill Lake (Missouri Dam No. 30073) with several dwellings along its shoreline, Missouri State Route B which is a medium-duty highway, and Missouri State Route 30 which is a heavy-duty highway. The dam is in the small size category due to its height of 29.2 feet and maximum storage capacity of 89 acre-feet. According to the size classification guidelines, a small size dam has a height greater than 25 feet but less than 40 feet and/or a maximum storage capacity greater than 50 acre-feet but less than 1,000 acre-feet.

The inspection and hydrologic and hydraulic analyses indicate that the spillway capacity of the dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The dam

will hold and pass approximately 23 percent of the Probable Maximum Flood (PMF) without overtopping. The Probable Maximum Flood is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 percent to 100 percent of the PMF. The dam has a relatively small height of 29.2 feet, a relatively small maximum storage capacity of 89 acre-feet, and a relatively small drainage area of 59 acres. The dwelling located approximately 0.4 miles downstream from the dam is about 10 feet above the downstream channel. All dwellings along the shoreline of Cedar Hill Lake are high enough above that lake that flooding of them appears unlikely. Considering these facts, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 1 percent probability flood (100-year flood) will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being equalled or exceeded in any given year.

The dam and spillway appeared to be in fair condition. Deficiencies visually observed by the inspection team included: (1) growth of trees, brush, and weeds on the embankment; (2) growth of trees and brush in the spillway channel; (3) irregular surface and variable slope of the downstream face; and (4) wet areas at the downstream right abutment, along the downstream toe of the dam, and just beyond the downstream toe of the dam at the left abutment. Another deficiency was the lack of seepage and stability analyses records.

It is recommended that the owners take the necessary action in the near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Brian Whiston

Brian Whiston, P.E.
Crawford, Murphy & Tilly, Inc.

Guy Freese

Guy Freese, P.E.
A & H Engineering Corporation

Timothy Tappendorf

Timothy Tappendorf, E.I.T.
Crawford, Murphy & Tilly, Inc.

PHOTOGRAPH 1. OVERVIEW OF LAKE ADELLE DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAKE ADELLE DAM
MISSOURI INVENTORY NO. 30411

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Lake Adelle Dam located in Jefferson County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, Recommended Guidelines for Safety Inspection of Dams. These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Lake Adelle Dam is an earthfill structure approximately 29.2 feet high and 580 feet long at the crest. The dam has a V-shaped spillway channel which is located in natural ground around the left end of the dam. In this report right and left orientation are based on looking in the downstream direction. There were five plastic pipes, each 1.5 inches in diameter, which pass through the dam about 2 feet below the crest, and which had been used as siphons to draw down the lake.

B. Location:

The dam is located about two miles south of Cedar Hill, Missouri, in Jefferson County on an unnamed tributary to Skullbones Creek. The longitude of the dam is 90^{o} 39.2' West and the latitude is 38^{o} 19.4' North. The dam is located in Section 2 and the watershed is located in Sections 1 and 2 of Township 41 North, Range 3 East of the 5th Principal Meridian. The

dam and watershed are within the Cedar Hill, Missouri 7.5 minute quadrangle map. Included in Appendix A are a location map on Plate 1 and a vicinity map on Plate 2.

C. Size Classification:

Lake Adelle Dam has an embankment height of approximately 29.2 feet and a maximum storage capacity of approximately 89 acre-feet. Therefore the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers, has classified this dam as a potential high hazard dam. The estimated damage zone extends approximately one and a half miles downstream of the dam to the Big River. Located within this zone are a sewage lagoon, a dwelling, a small lake, Cedar Hill Lake (Missouri Dam No. 30073) with several dwellings along its lake shoreline, Missouri State Route B which is a medium-duty highway, and Missouri State Route 30 which is a heavy-duty highway. The affected items within the damage zone were verified by the inspection team.

E. Ownership:

The dam is owned by Lake Adelle Property Owners, Inc., P. O. Box 26, Cedar Hill, Missouri 63016. Lake Adelle Property Owners, Inc. consists of the residents of the subdivision which surrounds the lake. The president at the time of the inspection was Mr. Doug Halbert, telephone 314-285-5366.

F. Purpose of Dam:

The dam was constructed to provide recreation and to enhance property within the subdivision which was developed around the lake.

G. Design and Construction History:

Information concerning the dam was obtained from Mr. Doug Halbert, president of Lake Adelle Property Owners, Inc. at the time of the inspection and from Mr. Ron Main who was chairman of the lake committee for the property owners. Information concerning the sewage lagoons located just downstream from the dam was obtained from Mr. Bill Giblin who was president of the Lake Adelle Sewer District.

The subdivision surrounding the lake was established in 1947 by a Mr. McKee who is deceased. The dam was believed to have been constructed about 1950. Mr. Halbert indicated that he knew of no recorded information on the design or construction of the dam.

Mr. Halbert said that to his knowledge no post-construction inspections have been made. The plastic pipes that have been used to draw down the lake

were installed after the original construction of the dam. Two sewage lagoons were built immediately downstream from the dam in about 1975. Sewers near the dam abutments and the downstream toe of the dam were also built after the original dam construction. Although it is not known if addition of these facilities resulted in modifications to the dam, it is felt that they merit mention due to their proximity to the dam. No other modifications to the dam are known to have occurred.

H. Normal Operating Procedures:

There is no operating equipment at the dam. Flows into the lake are passed by the uncontrolled spillway channel. According to Mr. Halbert the dam has never been overtopped and the maximum water level in the lake was 1 or 2 feet above the water level on the day of the inspection. No evidence of overtopping was noticed during the inspection.

Maintenance is the responsibility of the Lake Adelle Property Owners, Inc. Maintenance to the dam is normally performed on designated cleanup days by the residents of the subdivision. According to Mr. Halbert, maintenance of the dam was minimal until several years ago. In the last several years maintenance has included mowing the crest and upstream face of the dam, cutting down several trees on the upstream face and some clearing of brush on the downstream face of the dam.

1.3 PERTINENT DATA:

A. Drainage Area (Acres):	59.4
B. Discharge at Damsite (CFS):	
Maximum known flood at damsite	Unknown
Drawdown facility capacity at maximum pool	0.6
Spillway capacity at maximum pool	101
C. Elevation (Ft. Above MSL):	
Top of dam	623.5
Streambed at downstream toe of dam	594.3
Normal pool	621.1
Spillway crest	621.1
Pool elevation during inspection 25 Feb. '81	620.9
Apparent high water mark	None noted
Maximum tailwater	Unknown

D. Reservoir Lengths (Feet):

At top of dam	875
At spillway crest	850

E. Storage Capacities (Acre-Feet):

At top of dam	89
At spillway crest	73
At pool level during inspection 25 Feb. '81	71

F. Reservoir Surface Areas (Acres):

At top of dam	7.4
At spillway crest	6.65
At pool level during inspection 25 Feb. '81	6.55

G. Dam:

Type		Earthfill embankment
Length of crest (feet)		580
Height (feet)		29.2
Top width (feet)		10
Side slopes (Horiz.:Vert.)	Upstream	2.8H:1V (above water level)
	Downstream	Variable, see cross section on Plate 5 of Appendix A
Zoning		Unknown
Impervious core		Unknown
Cutoff		Unknown
Grout curtain		Unknown

H. Diversion and Regulating Tunnel: None

I. Spillway:

I.1 Principal Spillway:

Location	Around the left end of dam
Type	V-shaped channel in natural ground
Crest elevation (feet above MSL)	621.1
Channel U/S of control section	20' at 0.0% slope
Control section	20' at 0.0% slope
Channel D/S of control section	30' at 2.5% slope and 100' at 7.2% slope (see spillway flowline profile, Exhibit 4 of Appendix B)
Side slopes	Variable, see Exhibits 5 and 6 of Appendix B

I.2 Emergency Spillway: None

J. Regulating Outlets:

Location	100' right of left abutment
Type	5 PVC flexible plastic pipes, 1-1/2" diameter, used as siphons. They extend through dam about 2' below the crest & are submerged on the upstream end & extend 30' down the downstream face. Downstream ends of siphon pipes are uncapped.
Length (feet)	50 (est.)
Access to closure	No closure

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

According to Mr. Doug Halbert, who is the president of the Lake Adelle Property Owners, Inc., no engineering design data are known to exist for Lake Adelle Dam.

A. Surveys:

No detailed surveys are known to have been made of the dam.

B. Foundation and Embankment Design:

No foundation and embankment design computations are known to exist.

C. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations are known to exist.

2.2 CONSTRUCTION:

According to Mr. Halbert the subdivision surrounding Lake Adelle was developed in 1947. He believes the dam was built in about 1950. No other information regarding the construction of the dam is available. Except for the installation of the drawdown siphon pipes and the construction of the sewage lagoons near the downstream toe of the dam, no other modifications to or near the dam are known to have occurred.

2.3 OPERATION:

There is no operating equipment at the dam. There are five flexible plastic pipes which are 1.5 inches in diameter and extend through the dam which have been used as siphons to draw down the lake. It was not determined how the siphons are placed into operation, nor is it known to what level the lake can be lowered using the siphons. They are reported to have been used only once in the past. Outflow normally passes through the uncontrolled spillway channel. According to Mr. Halbert the dam has never been overtopped and no evidence of overtopping was observed during the inspection.

2.4 EVALUATION:

A. Availability:

No engineering data for Lake Adelle Dam were available and it is believed that such data do not exist.

B. Adequacy:

Due to the fact that no engineering data were available, a detailed assessment of the design, construction, and operation of this structure could not be made. The fact that no seepage and stability analyses comparable to the requirements of the Recommended Guidelines for Safety Inspection of Dams were available is a deficiency which should be rectified. The seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

No conclusions can be drawn concerning the validity of the original design analysis due to unavailability of such analysis.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on 25 February 1981. The inspection team consisted of personnel from Crawford, Murphy & Tilly, Inc. of Springfield, Illinois and from A & H Engineering Corporation, Carbondale, Illinois. The members were:

Brian Whiston, P.E. - Crawford, Murphy & Tilly, Inc.
Guy Freese, P.E. - A & H Engineering Corporation
Timothy Tappendorf, E.I.T. - Crawford, Murphy & Tilly, Inc.

The field inspection included the determination of dimensions and elevations of the dam and appurtenances necessary to show as a minimum a plan view, a dam crest profile, a spillway profile and section, and pertinent cross sections of the dam. For this report all elevations were obtained using a USGS third order benchmark located near the intersection of Missouri State Route B and the road leading to the subdivision surrounding Lake Adelle. The benchmark is designated "TT34L1930704" and is a concrete post with marker and has an elevation of 704.515 feet above Mean Sea Level. A visual inspection of the dam, spillway, drainage area, and downstream channel was performed and photographs were taken of each of these features.

No one accompanied the inspection team during the inspection. Mr. Doug Halbert, president of the Lake Adelle Property Owners, Inc. and Mr. Ron Main, chairman of the lake committee, were interviewed following the inspection. Also, Mr. Bill Giblin, who is sewer district president in charge of the sewage lagoons just downstream from Lake Adelle Dam, was interviewed by phone following the inspection. A map showing the location of the sanitary sewers near the dam and downstream sewage lagoons was obtained from Mr. Giblin and pertinent data obtained from the map is included on Plate 4 of Appendix A.

Maps and general drawings of the dam and appurtenances are presented on Plates 1 through 5 in Appendix A and a hydrologic and hydraulic analysis is presented in Appendix B. Photographs of the dam and appurtenances are presented in Appendix C.

B. Regional and Project Geology:

The general subsurface geology of Jefferson County consists of Precambrian bedrock overlain by Paleozoic formations. The Mesozoic Era is locally absent throughout most of this area and the Cenozoic Era is represented usually in surface deposits.

The major structural features in Missouri consist of the Ozark uplift with subsequent basins and numerous glacial features including the major river systems (Mississippi and Missouri).

Precambrian bedrock in Jefferson County is comprised of felsites and granites of the St. Francois Mountains. Jefferson County lies almost directly north of the St. Francois Mountains. These igneous rock formations are overlain uncomformably by the oldest Paleozoic rock formations.

Paleozoic rock formations consist primarily of Cambrian and Ordovician aged rock. The structural attitude of these Paleozoic formations is controlled by the shape of the Ozark uplift. The apex of this uplift lies in the St. Francois Mountains. Rock units dip away from the apex of this uplift to the northwest through the Forrest City basin and northeast through the Illinois basin. The Mississippi River valley dominates Paleozoic exposures in the eastern sections of Jefferson County including Mississippian age bedrock and some tertiary and quaternary deposits. However, due to the uplift, Ordovician aged bedrock is the dominant rock formation exposed throughout the rest of Jefferson County.

The actual limits of the three glacial advances (Illinoian, Kansan, and Nebraskan) in Missouri appeared to stop just north of Jefferson County. Glacial runoff deposits, especially along the Mississippi River and tributaries, and recent river alluvium are found through Jefferson County.

The soil cover at the site consists of a relatively thin layer of modified loess (ML-CL). Exposed on the slopes of the downstream channel and slopes of the abutments is an underlying stratum of reddish cherty residuum. This material covers most of the Ozark uplift and varies in thickness in the project area from 0 to approximately 50 feet. The cherty residuum is usually regarded as being of Cenozoic age, but much of it may have accumulated during the Mesozoic Era.

The underlying dolomite bedrock is exposed to the north of the dam site and also a number of boulders were observed along the bottom of the discharge channel. The bedrock appears to be the Jefferson City-Cotter formation of the Canadian series of the Ordovician system. This formation consists of a fine grained silty and cherty dolomite with oolitic chert and some shale members. The Roubidoux and Gasconade formations underlie the Jefferson City-Cotter formation and consist generally of sandstone and cherty dolomite.

The dam site is located in Seismic Zone 2 as shown on Plate 3 of Appendix A.

C. Dam:

Lake Adelle Dam is an earthfill dam with a height of approximately 29.2 feet and length at the crest of approximately 580 feet. The spillway is a V-shaped channel in natural ground around the left end of the dam. There are two sewage lagoons located just beyond the downstream toe of the dam and several sanitary sewer manholes located near the left and right abutments and the downstream toe of the dam. The overall condition of the dam appeared to be fair.

The horizontal alignment of the dam appeared fairly uniform. The horizontal alignment of the crest of the dam was a straight line and the crest had a width of approximately 10 feet. The crest had a grass cover which had been recently mowed. A view of the crest is given on Photograph 3.

The elevation of the centerline of the crest of the dam varied from 623.5 to 625.4. Although there is a 1.9 foot variation in the crest elevation, much of the difference is due to the higher elevations at the abutments, and the vertical alignment is relatively uniform. The profile of the dam crest is shown on Exhibit 3 of Appendix B.

The upstream face of the dam had a slope of approximately 2.8 horizontal to 1 vertical. The upstream face had several trees, bushes, and tree stumps on it. According to Mr. Doug Halbert, the tree stumps were left from trees which had been cut down in the past two years. The upstream face of the dam had a grass cover which had been kept mowed. Erosion from wave action on the upstream face of the dam was minimal, indicating that the absence of riprap or other slope protection near the normal pool level is not a deficiency. Some scattered pieces of limestone were noted along the water's edge just below the waterline. These pieces of rock were apparently part of the fill and had been exposed by washing of the surface soil. A view of the upstream face is given in Photograph 2.

The downstream face of the dam had a slope which varied from about 1.9 horizontal to 1 vertical to about 3.0 horizontal to 1 vertical and also had a rather irregular surface. A typical cross section of the dam can be seen on Plate 5 of Appendix A. The downstream face of the dam was generally irregular. The exact cause for the variation in slope and the surface irregularity could not be determined but did not appear to be the result of sloughing and was probably the result of the original construction and some erosion. The variation in slope and the surface irregularity did not appear to be related to the variations in the dam crest elevations. The downstream face had a heavy brush cover and had several trees on it. There were several piles of brush and branches as a result of clearing which was reported to have taken place in the previous year. The heavy brush inhibited a thorough inspection of the downstream face. Two views of the downstream face are given on Photographs 4 and 5.

There are two sewage lagoons located just downstream of the dam as shown on Plate 4 of Appendix A. The sewage lagoons are shown in several photographs in Appendix C. There are several sanitary sewer manholes located near or on the dam. A map showing the layout of the sewers near the dam was obtained from Mr. Bill Giblin and those pertinent to this inspection are shown on Plate 4. As noted on Plate 4, there are gravity flow sewers extending from a manhole located near each abutment to a manhole located near the toe of the dam. These sewers are buried in the embankment fill but the depth, condition, and material of construction of these sewers could not be determined. The sewers flowing into the manholes at each abutment are 8 inch and 6 inch vitrified clay pipe according to the sewer map obtained, but the outfall sewers were constructed at a later date and no information was available for them.

There were some scattered areas of minor erosion on the dam. There were no erosion gullies of any significance observed. No surface cracks or unusual movement or cracking at or beyond the toe of the dam was noticed. No foundation drains were observed at the dam. No evidence was found of animal holes or burrows on the embankment, although the brush on the downstream face may have obscured some animal holes. Mr. Halbert indicated that someone traps on the dam occasionally.

There were cattails growing at the downstream right abutment and just beyond the toe of the dam at the left abutment. The cattails indicated that those areas have had standing water or have been damp most of the time. A small amount of standing water was seen at the right abutment and the ground was damp and soft in the area where the cattails were located. This water was clear and was not observed to be flowing. The wet area may have been the result of exfiltration from the sewer which runs from the manhole near the right abutment to the sewage lagoons. A view of the cattails at the right abutment is given in Photograph 8.

There is a V-shaped ditch along the downstream toe of the dam between the dam embankment and the sewage lagoon embankment. This ditch also had some clear standing water in it. It appeared that cattails had been growing in this ditch but that they had been cut down when the grass around the lagoons was mowed. The source of this standing water could not be determined and may have come from seepage from the lake, seepage from the sewage lagoon, surface runoff, or a combination of the three.

There were cattails located just beyond the downstream toe of the dam at the left abutment and in the ditch leading from this area to the downstream discharge channel. This area can be seen in Photograph 9. The area beyond the toe had clear standing water and a small flow of clear water was noticed where the ditch leading from this area joined the discharge channel. The source of the water in this area could not be determined. The water may be the result of seepage from the lake, seepage from the sewage lagoons, surface runoff, a high water table level, or exfiltration from sewers near the sewage lagoons.

A shallow soil sample was obtained from the embankment near the center of the crest. The sample was classified as a light brown silty clay with traces of rock fragments (CL).

D. Appurtenant Structures:

D.1 Spillway:

The spillway is a channel in natural ground around the left end of the dam. The approach channel is a broad U-shaped channel with an approximate width of 18 feet. It is about 20 feet long and has a grass cover with some limestone pieces exposed along the channel bottom. There appeared to have been concrete lining along one side of the approach channel near the shoreline. The concrete was only several feet square and was partially covered with soil and grass. A view of the approach channel is given in Photograph 6.

Downstream from the approach channel, there is a nearly level crest section about 20 feet long followed by 30 feet at a 2.5% slope followed by 100 feet at a 7.2% slope. This channel is V-shaped and is lined with grass, brush, and small trees. There were pieces of limestone along the sides and bottom of the channel and most of the bottom of the channel section with the 7.2% slope consisted of limestone. A view of the spillway channel is given on Photograph 7. The spillway flowline profile is shown on Exhibit 4 and spillway cross sections are shown on Exhibits 5 and 6 of Appendix B.

The flow from the spillway channel exits onto a wide, relatively flat area that has no well-defined channel. The flow spreads out and the exact path that it takes is not known. Some of it apparently flows to the area just beyond the downstream toe of the dam at the left abutment and some of it flows into the channel which flows from the hillside just west (left) of the dam.

D.2 Emergency Spillway:

There is no emergency spillway at the damsite.

D.3 Drawdown Facility:

The drawdown facility consists of 5 flexible PVC pipes, each 1.5 inches in diameter, used as siphons to draw down the lake. The pipes are located about 100 feet right of the left abutment. They extend from below the normal pool level on the upstream side of the dam, through the dam, and exit the embankment about 2 feet below the crest of the dam on the downstream face and then extend approximately 30 feet down the downstream face of the dam. According to Mr. Doug Halbert the drawdown facility has only been used once to draw the lake down several feet. The downstream ends of the siphon pipes were uncapped and had no flow. The upstream ends could not be observed. It could not be determined whether the upstream ends of the siphons are capped, nor was it determined how the siphons are operated.

E. Reservoir and Watershed:

The watershed for Lake Adelle Dam contains approximately 59.4 acres. The surface area of the lake is about 11% of the watershed area when it is at the spillway crest elevation of 621.1 and about 12.5% when it is at the top of dam elevation of 623.5. A view of the lake and residential development surrounding it is given on Photograph 10. The watershed consists of a residential subdivision with average slopes of 14% to 18%.

No soil survey of Jefferson County had been done by the Soil Conservation Service therefore the soil in the watershed had not been classified. The soil was assumed to be in hydrologic Group B-C as defined by the SCS for the determination of runoff curve numbers. This assumption is based on the regional geology and discussions with the Missouri State Soil Conservation Service personnel. According to Mr. Doug Halbert there is a sedimentation problem at the three main coves of the lake. They have been partially filled in with gravel from the roadways and silt from the main drainage ditches. Apparently the sedimentation is primarily in the coves at the upstream reaches of the lake. Shoreline erosion appeared to be minor.

Mr. Halbert indicated that the lake level does not fluctuate much and that even though there had been a long dry spell prior to the inspection the lake was only 0.2 feet below the spillway crest. He said there was hearsay that several springs may be present in the lake area. Mr. Halbert also said that there has been substantial algal growth in the lake.

F. Downstream Channel:

Flow from the wet area near the downstream left abutment and flow in a channel from the hillside immediately west of the dam join just outside the fence on the west side of the sewage lagoons as shown on Plate 4 of Appendix A. From that point to just downstream of the sewage lagoon outlet the channel is trapezoidal with a rock bottom and earth and rock sides. The flow then enters the original stream channel. A view of the discharge channel near the sewage lagoon outlet is given on Photograph 11.

The original downstream channel is a trapezoidal channel and is heavily wooded with underbrush. A view across the sewage lagoons at the downstream channel is given in Photograph 12. The channel has an average slope of about 3% for 0.5 miles downstream of Lake Adelle before it flows into two small lakes. Of the two lakes, the furthest downstream is Cedar Hill Lake (MO 30073). The other lake, located immediately upstream of Cedar Hill Lake, was originally in series with Cedar Hill Lake, but has been modified to include a berm along the right side of the channel to form the present side channel lake and channel dam. Downstream of these lakes the channel continues for another 0.2 miles before its confluence with Skullbones Creek. Photograph 13 shows a view from the bank of the downstream channel of a dwelling located

0.4 miles downstream from Lake Adelle Dam. Photograph 14 shows one of the lakes located 0.5 miles downstream from the dam. The downstream channel and downstream lakes can be seen on Exhibit 1 in Appendix B.

3.2 EVALUATION:

The brush, weeds, and bushes on the dam should be cleared so that future inspections may be more thorough and to remove cover for animals that might burrow in the dam. A grass cover should be started in place of the brush to provide adequate erosion protection. Trees located on the dam can present potential stability and seepage problems. As the trees continue to grow, the root system could go laterally through the embankment and provide seepage paths. Also if the trees are blown over during a storm, large sections of the embankment can be weakened. It would be desirable to cut the trees, remove the stumps, fill and compact the holes, and restore the vegetation on the disturbed areas.

The brush and small trees in the spillway channel should be cleared and should be replaced with a suitable vegetal cover which will minimize scour and erosion in the channel but which will be less restrictive to the flow.

The wet areas at the right abutment and along the downstream toe of the dam should be filled and graded to drain. These areas should then be monitored and if they continue to stay wet, the source of the water should be determined and corrective action taken if deemed necessary.

The steep and irregular slopes of the downstream face present a condition that may contribute to instability. It should be noted that Lake Adelle Dam is located in Seismic Zone 2 as shown on Plate 3 of Appendix A. A Seismic Zone 2 delineates areas in which moderate damage would result from the expected seismic activity in the area. The lack of seepage and stability analyses is a deficiency which should be corrected. Seepage and stability analyses should include an allowance for seismic loadings.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The only operating equipment at Lake Adelle Dam is the drawdown facility consisting of 5 PVC pipes used as siphons. The drawdown facility is reported to have only been used once and there is no schedule of operation. The water level in the lake is controlled by rainfall, runoff, evaporation, and overflow through the spillway channel.

4.2 MAINTENANCE OF DAM:

Maintenance of the lake and dam is the responsibility of the Lake Adelle Property Owners, Inc. According to Mr. Doug Halbert, maintenance of the dam was minimal until the last several years. In the past several years the crest and upstream face of the dam have been kept mowed. Several trees have been cut down on the upstream face of the dam and some of the brush on the downstream face has been cut and put in piles.

Mr. Halbert indicated that maintenance is performed by the residents of the subdivision surrounding the lake on a volunteer basis. He stated that several days each year are designated "clean-up days" and most of the work is done on these days.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities requiring maintenance at the dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

No warning system is known to exist.

4.5 EVALUATION:

The dam and spillway maintenance should be improved. The trees, brush, and weeds on the dam should be removed and an adequate grass cover be promoted as stated in Section 3.2. The trees and brush in the spillway channel should be removed and should be replaced with a suitable vegetal cover which will minimize scour and erosion but which will be less restrictive to the flow. Maintenance should be performed on a regular basis and a record of the maintenance performed should be kept.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydraulic or hydrologic design data for Lake Adelle Dam are known to exist.

The significant dimensions of the dam and reservoir were measured or surveyed on the date of inspection or estimated from available topographic mapping. The map used in the analysis is the 7.5 minute U.S. Geological Survey quadrangle sheet for Cedar Hill, Missouri, dated 1954 and photorevised 1968 and 1974.

B. Experience Data:

No recorded rainfall, runoff, discharge, or lake stage data were available for the lake and watershed. Information obtained from Mr. Doug Halbert indicated that the highest the lake level has been was 1 or 2 feet above the water level on the day of the inspection.

C. Visual Observations:

Descriptions of the watershed, dam, lake, spillway, and drawdown facility are given in Section 3. The lake level is controlled by flow through the spillway channel. According to Mr. Doug Halbert the dam has never been overtopped and no evidence of overtopping was observed during the inspection. The crest of the spillway is 2.4 feet below the top of the dam.

A description of the downstream channel is given in Section 3.1F. The downstream hazard zone extends approximately 1.5 miles downstream from the dam to the Big River and includes a sewage lagoon, a dwelling, an unnamed lake, Cedar Hill Lake (Missouri Dam No. 30073) with several dwellings along its shoreline, Missouri State Route B which is a medium-duty highway, and Missouri State Route 30 which is a heavy-duty highway.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix B, the dam and spillway have the capacity to store and pass approximately 23% of the Probable Maximum Flood (PMF) without being overtopped. The Probable Maximum Flood is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this dam, which is in the small size category with a high downstream hazard

potential classification, pass 50% to 100% of the PMF without overtopping. The dam has a relatively small height of 29.2 feet, a relatively small maximum storage capacity of 89 acre-feet, and a relatively small drainage area of 59 acres. The dwelling located approximately 0.4 miles downstream from the dam is about 10 feet above the downstream channel. All dwellings located along the shoreline of Cedar Hill Lake are high enough above the lake that flooding of them appears unlikely. Considering these facts, 50 percent of the PMF has been determined to be the appropriate spillway design flood. Thus the spillway capacity of this dam is considered inadequate. The dam and spillway will hold and pass a 1% probability flood without overtopping the dam.

Data for the 23% PMF, 50% PMF, and the 100% PMF are presented in the table below:

Percent PMF	Starting Pool Elevation (MSL)	Peak Inflow To Lake (cfs)	Maximum Pool Elevation (MSL)	Maximum Depth Over Dam (feet)	Peak Discharge (cfs)	Overtopping Duration (hour)
23%	621.1	309	623.45	0	97	0
50%	621.1	672	624.42	0.92	515	2.75
100%	621.1	1343	624.80	1.30	1209	6.17

The starting pool elevations were found by assuming that the lake level was at the crest of the principal spillway elevation of 621.1 and then applying an appropriate antecedent storm four days prior to the storm being analyzed. The antecedent storm for the analysis of the PMF ratio storms is a storm half the magnitude of the storm being analyzed. All of the inflow to the lake from the antecedent storms passes through the spillway and results in a starting elevation at the spillway crest for the analysis of the 23%, 50%, and 100% PMF.

The capacity of the spillway when the lake level is at the top of the dam is 101 cfs.

The dam will be overtopped by flood flows of less magnitude than the spillway design flood. Overtopping of an earthen embankment could cause serious erosion and lead to failure of the structure. Flood discharges resulting from a failure of Lake Adelle Dam could be expected to produce substantial stage rises in the hazard zone. Overtopping would lead to potential loss of life and potential extensive economic losses.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Section 3 of this inspection report.

B. Design and Construction Data:

Design data for this dam were unavailable.

Seepage and stability analyses comparable to the requirement of the inspection guidelines were also not available. This situation constitutes a deficiency which should be corrected.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The only post-construction changes have been the installation of the drawdown siphon pipes and the construction of the sewage lagoons near the downstream toe of the dam.

E. Seismic Stability:

This dam is located in Seismic Zone 2, as shown on Plate 3 of Appendix A. Zone 2 delineates areas in which moderate damage would result from the expected seismic activity in the area. In general, it is anticipated that an earthquake of this magnitude would not cause severe structural damage to a well constructed earth dam of this size. However, a slope stability analysis should be performed, as indicated in the inspection guidelines, to determine if static stabililty conditions are satisfactory and conventional safety margins do exist for this earth dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

A. Safety:

Several items were noted during the field inspection that could adversely affect the safety of the dam. These items are: (1) irregular surface and variable and some relatively steep slopes on the downstream face; (2) large trees on both the upstream and downstream faces of the dam; (3) brush and trees in the spillway channel which may cause restriction to flow; and, (4) wet areas at the downstream right abutment, along the toe of the dam, and just beyond the toe at the left abutment.

Another deficiency was the lack of seepage and stability analyses. This deficiency should be corrected, especially in consideration of the relatively steep slopes of the downstream face of the dam. The wet areas on the dam should be monitored to determine if the water is seepage through the dam or under the dam or exfiltration from the sewers. The results of the monitoring should be included in the seepage analysis.

The dam will be overtopped by flows in excess of 23 percent of the Probable Maximum Flood. Overtopping of Lake Adelle Dam could cause serious erosion and could posssibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, visual observation of external conditions and data from available mapping. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the Recommended Guidelines for Safety Inspection of Dams were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in Section 7.2 should be accomplished in the near future. If the deficiencies listed in Paragraph A are not corrected, and if good maintenance is not provided, the embankment condition could deteriorate and could possibly become serious in the future. The deficient spillway capacity should be given a high priority.

D. Necessity for Additional Inspection:

Based on the results of the Phase I inspection, additional periodic inspections are recommended. Inspections are also recommended after major flood events.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Recommendations:

1. The hydraulic capability of this dam should be increased to safely hold and/or pass the recommended Spillway Design Flood which is 50 percent of the PMF. This is normally accomplished by one or more of the following alternative measures:

   (a) Construction of additional erosion free spillway capacity.

   (b) Provision for additional flood storage by:

      i. Increasing the height of the dam.

      ii. Permanently reducing the normal pool elevation.

2. Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams. Since the dam is located in Seismic Zone 2, the analyses should include the appropriate seismic loadings. The seepage analysis should include the possibility of exfiltration from the sewers in the dam.

3. Trees should be removed from the embankment. All disturbed areas should be reshaped and seeded.

4. The wet areas at the downstream right abutment, along the downstream toe of the dam, and just beyond the downstream toe at the left abutment should be filled or graded to drain. The wet areas should be monitored and if they remain after the grading, the source of water should be determined and appropriate measures should be taken.

B. Operation and Maintenance Procedures:

1. The brush and bushes should be removed from the embankment. All disturbed areas should be repaired and reseeded.

2. The trees and brush in the spillway channel should be removed and the channel kept free of obstructions.

3. A good permanent vegetal cover should be established on the embankment slopes and spillway channel.

4. A detailed inspection of the dam should be made periodically and following major flood events by an engineer experienced in the design and construction of dams. Records should be kept of these inspections and maintenance efforts.

PHASE I INSPECTION REPORT

APPENDIX A

MAPS AND GENERAL DRAWINGS

APPENDIX A

MAPS AND GENERAL DRAWINGS

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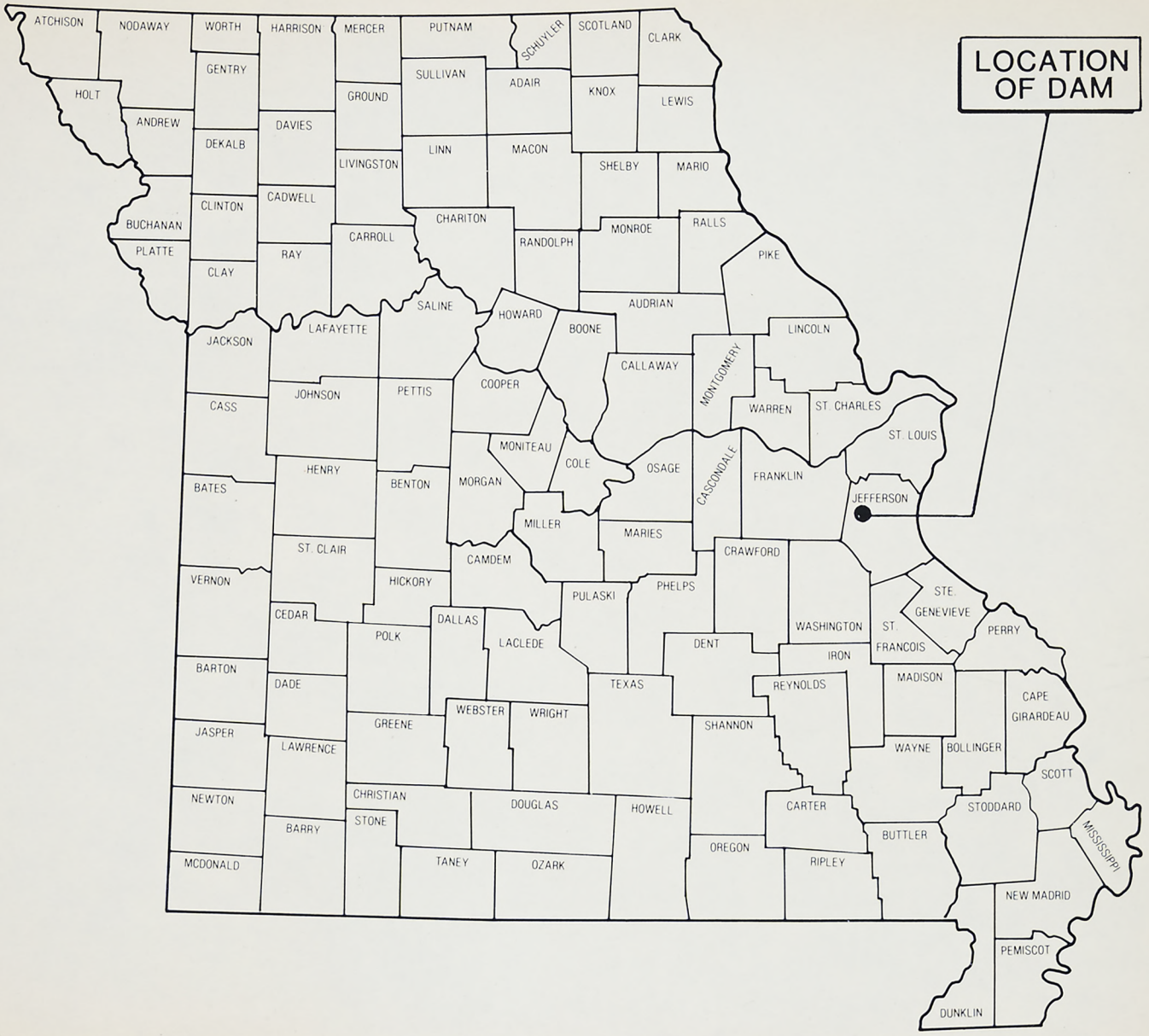

PLATE 1

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers
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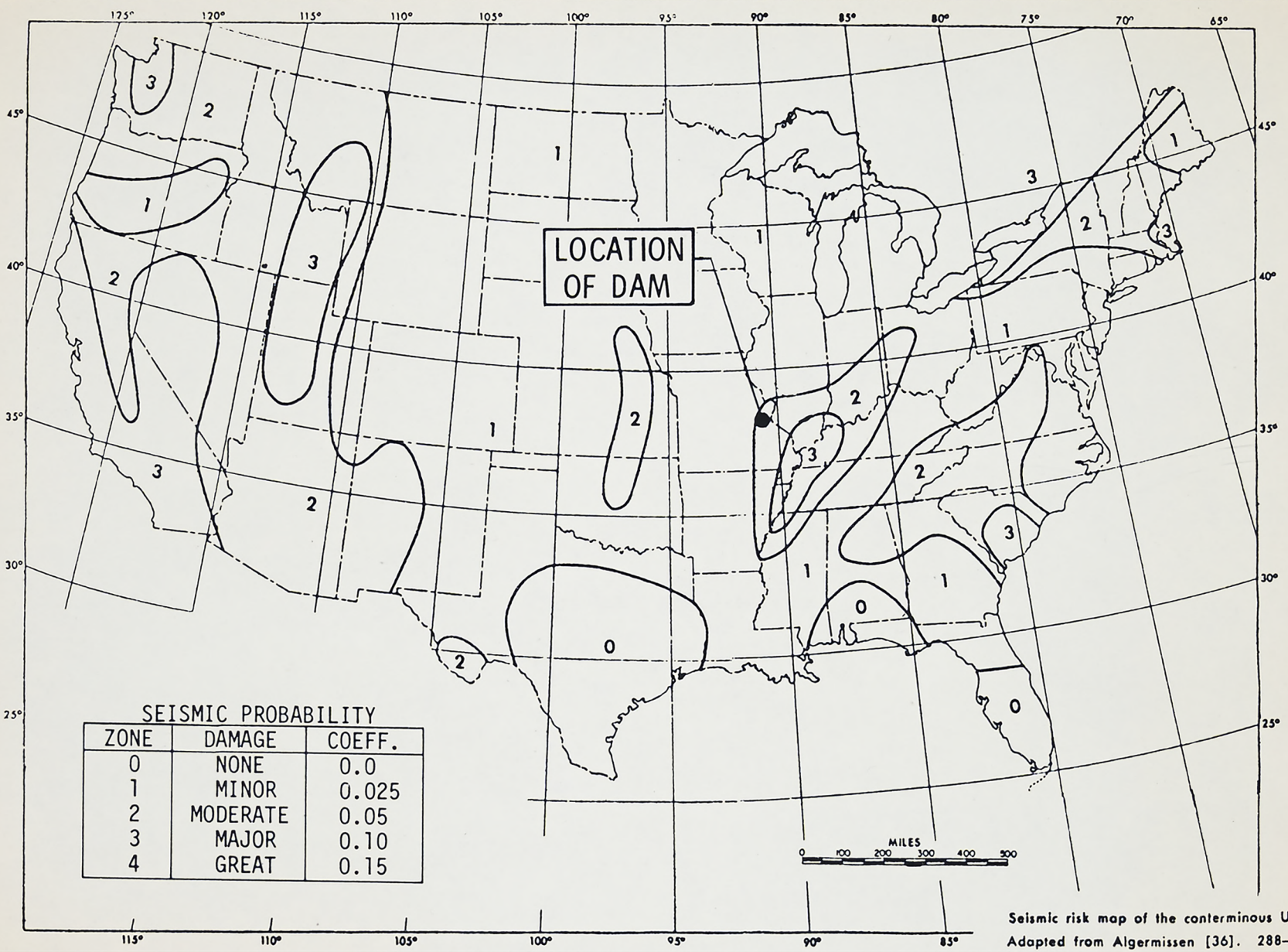
U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

LOCATION MAP

LAKE ADELLE DAM MO. 30411

CM&T	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	VICINITY MAP LAKE ADELLE DAM MO. 30411

PLATE 2



SEISMIC PROBABILITY

ZONE	DAMAGE	COEFF.
0	NONE	0.0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

Seismic risk map of the conterminous United States.
Adapted from Algermissen [36]. 288-D-2786.

PLATE 3

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers
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U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

SEISMIC ZONE MAP OF CONTIGUOUS STATES
LAKE ADELLE DAM MO. 30411

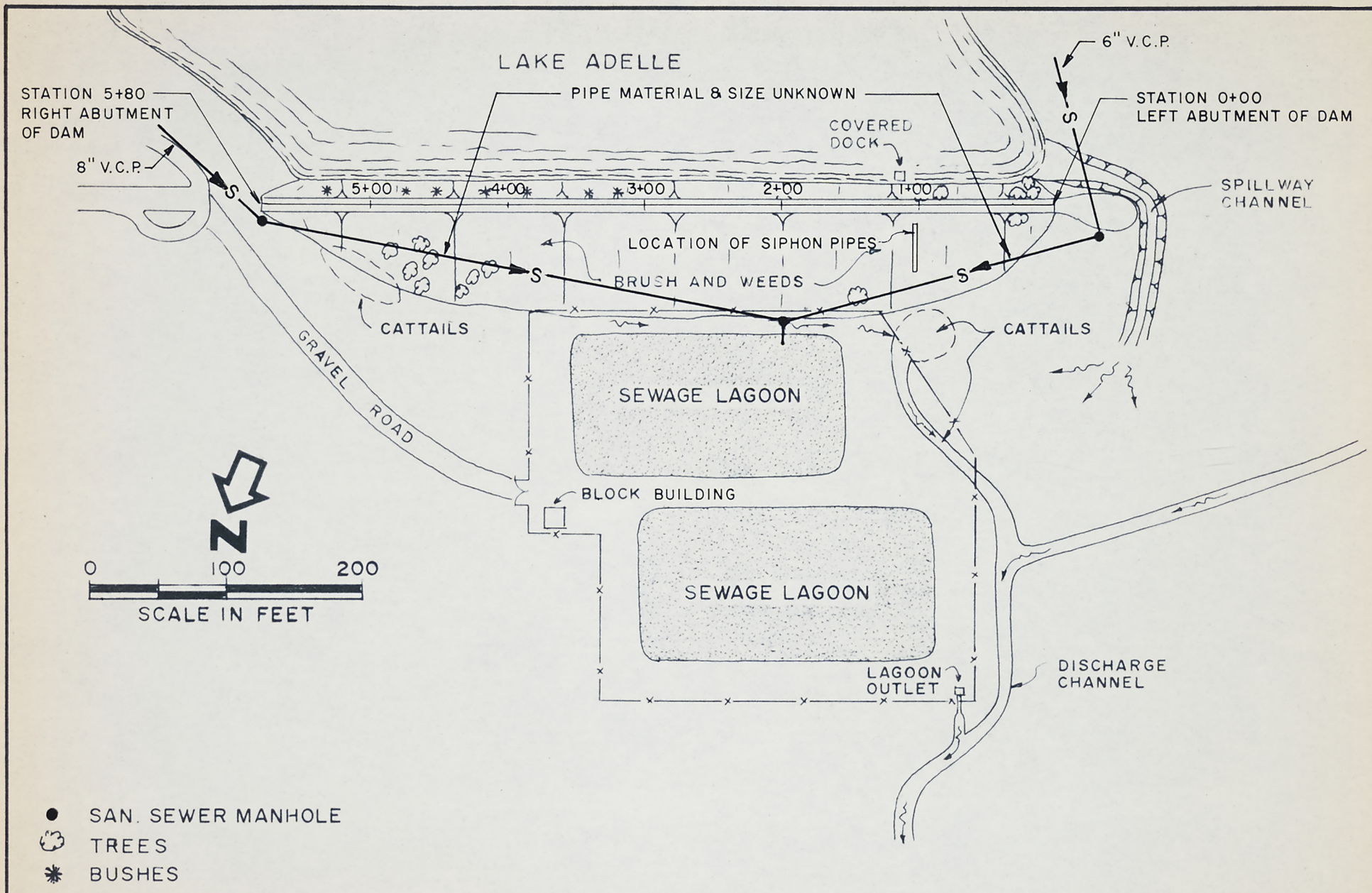

PLATE 4

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers
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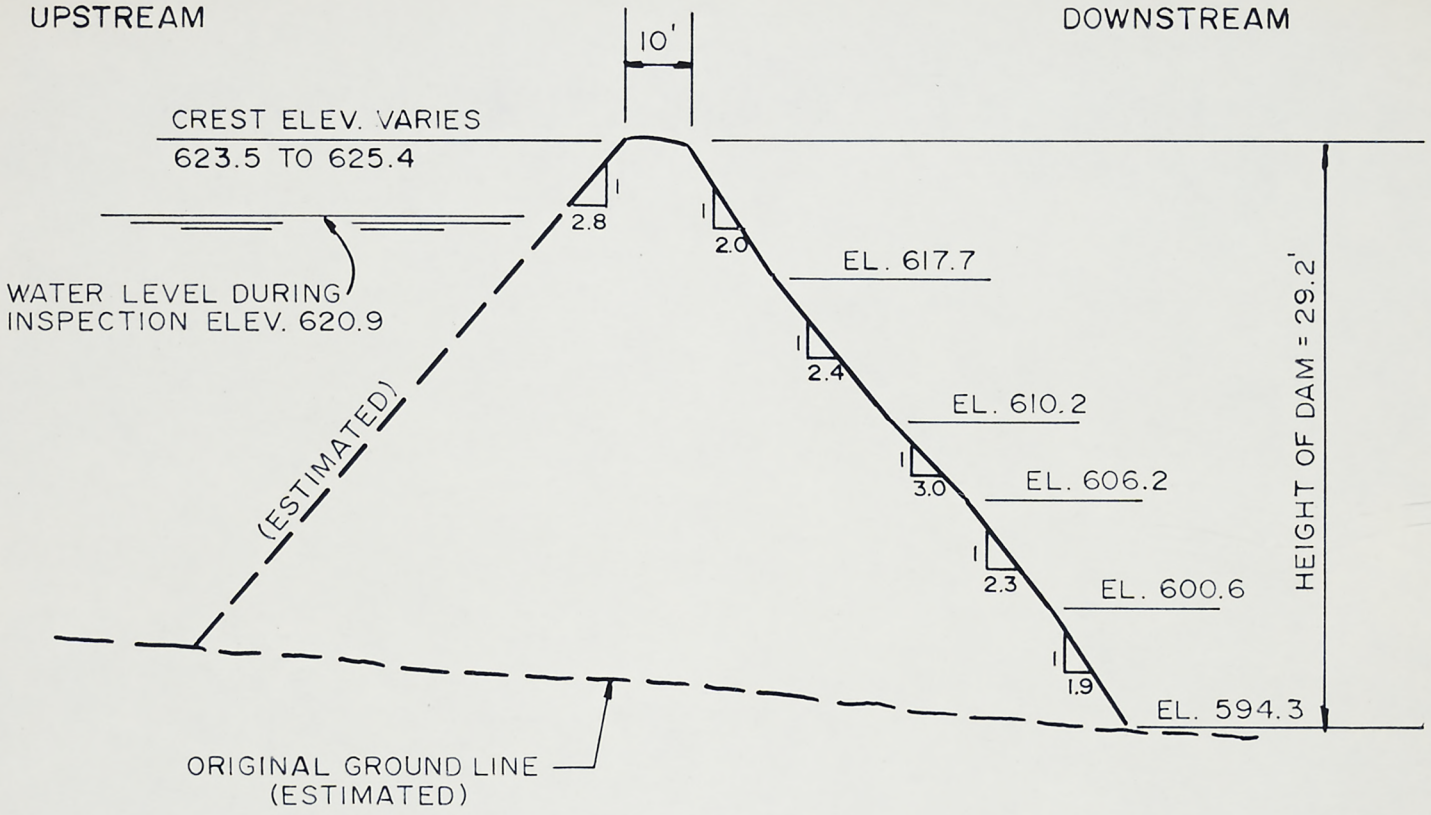
U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

PLAN OF DAM AND SPILLWAY
LAKE ADELLE DAM MO. 30411



TYPICAL CROSS SECTION OF DAM

APPROXIMATE SCALE
HORIZ. 1" = 30'
VERT. 1" = 10'

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	CROSS SECTION OF DAM LAKE ADELLE DAM MO. 30411

PLATE 5

PHASE I INSPECTION REPORT

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

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EXHIBITS

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

A. PURPOSE:

The purpose of this Appendix is to present the methodology used and the results of the hydrologic and hydraulic analysis. The analysis was done according to criteria presented in the Recommended Guidelines for Safety Inspection of Dams and in the St. Louis District Hydrologic/Hydraulic Standards for Phase I Safety Inspection of Non-Federal Dams dated 22 August, 1980. The purpose of the analysis is to determine the overtopping potential of Lake Adelle Dam.

B. HYDROLOGIC AND HYDRAULIC ANALYSIS:

The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. Data for determination of the unit hydrograph was obtained from the U. S. Geological Survey 7.5 minute quadrangle map for Cedar Hill, Missouri, dated 1954, and photorevised in 1968 and 1974 and from the field inspection. A lake and watershed map is shown on Exhibit 1. The parameters used in the development of the unit hydrograph are presented in Table 1.

TABLE 1

UNIT HYDROGRAPH PARAMETERS

Drainage Area (A)	0.093 sq. miles
Time of Concentration (Tc) - computed using overland plus channel flow times	0.20 hours
Lag Time (Lg)	0.12 hours
Time to Peak (Tp)	0.16 hours
Peak Discharge (Qp)	280 cfs
Duration (D) (smallest HEC-1 allows)	0.083 hours (5 minutes)

Unit Hydrograph from the HEC-1 Computer Output

Time (Minutes)	Discharge (cfs)
0	0
5	140
10	279
15	175
20	72
25	31
30	13
35	6
40	3
45	1

Formulas Used:

$$Lg = 0.6\ Tc$$

$$Tp = D/2 + Lg$$

$$Qp = \frac{484\ A\ Q}{Tp}$$

Q = Excess Runoff = 1 inch

The hypothetical storm that is applied to the unit hydrograph is the Probable Maximum Precipitation (PMP). It is derived and determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." No reduction factors have been applied to the PMP. A 24 hour storm duration is assumed with total depth distributed over 6 hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF determination). The maximum 6 hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The non-peak 6 hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF. The final inflow hydrograph is produced by deduction of infiltration losses appropriate to the soil, land use, and antecedent moisture conditions. Soil type, land use, and slopes were determined from the field inspection, discussions with Missouri State Soil Conservation Service personnel, and available mapping and are presented in Section 3. Antecedent Moisture Condition III (AMC III) was used for the analysis of the PMP percentage storms.

A 1 percent probability (100-year) storm was also analyzed. The rainfall amount and distribution for the 1 percent probability storm with a 24 hour duration for a drainage area of 0.5 square miles for the St. Louis, Missouri area was obtained from the St. Louis District, Corps of Engineers, and used for the analysis. AMC III was used for the analysis of the 1 percent probability storm. The rainfall applied, the parameters used to determine infiltration losses, and the resulting runoff are presented in Table 2.

TABLE 2

RAINFALL-RUNOFF PARAMETERS

Selected Storm Event	Storm Duration (hours)	Rainfall (inches)	Runoff (inches)	Losses (inches)
PMP	24	34.45	33.43	1.02
1% Probability Storm	24	6.95	5.91	1.05

Additional Data

1. Soil Conservation Service Runoff Curve Number = 91 (AMC III) for the PMF ratio storms and 1% probability storm.
2. Percentage of Drainage Basin Impervious = 12%.

The reservoir routing is accomplished by using the Modified Puls routing technique in which the flood hydrograph is routed through lake storage. The hydraulic capacity of the spillway and the crest of the dam are used as outlet controls in the routing. Storage in the pool area is defined in an elevation-storage capacity curve. The hydraulic capacity of the spillway and top of the dam are defined by elevation-discharge curves.

The elevation-storage capacity curve was developed by determining the lake surface area at various elevations using available mapping and then inputting this information to the HEC-1 computer program. The computer program then developed an elevation-storage capacity curve using the conic method. An Elevation-Area-Capacity curve is shown on Exhibit 2.

For the overtopping analysis, the top of the dam is the lower of the following elevations: (1) The minimum elevation of embankment as determined by simple field surveys. (2) The lake elevation at which corresponding outflow velocities, as determined from simple hydraulic formula, exceed the suggested maximum permissible mean channel velocities in the spillway. The top of the dam was determined to be 623.5 which is the minimum elevation of the embankment. Outflow velocities in the spillway when the lake is at this elevation are at or below the suggested maximum permissible mean channel velocities for grass lined channels with silt clay soil. Therefore only minor erosion of the spillway channel is expected by flows when the lake level is at or below the top of the dam.

The elevation-discharge capacity curve for the top of the dam was developed using the non-level crest option of the HEC-1 computer program. The program assumes critical flow over a broad-crested weir. A profile of the dam crest is given on Exhibit 3.

The hydraulic capacity of the principal spillway was determined using step backwater computations. Cross sections, slopes, and channel roughness were used to compute the head losses in the spillway channel to determine a lake elevation for several selected discharges. The profile of the spillway flowline is shown on Exhibit 4 and spillway cross sections are shown on Exhibits 5 and 6. A view of the spillway channel is shown on Photograph 7. A roughness coefficient of "n" equal to 0.08 was used for the step backwater computations. The lake elevation vs. spillway discharge data that was input to the computer is shown in Table 3.

TABLE 3

LAKE ELEVATION VS. SPILLWAY DISCHARGE

Lake Elevation (MSL)	Spillway Discharge (cfs)
621.1	0
621.5	2.4
622.0	12.5
622.5	32.0
623.0	62.5
623.5	101
624.0	156
624.5	238
625.0	340

The dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This analysis determines the percentage of the PMF hydrograph that the reservoir can contain without the dam being effectively overtopped. According to Hydrologic/Hydraulic Standards developed by the Corps of Engineers, St. Louis District, an antecedent storm should be applied to the watershed before analysis of the PMF. The antecedent storm precedes the storm being analyzed by 4 days. The starting elevation at the beginning of the antecedent storm was assumed to be at the elevation of the spillway crest. The antecedent storm for the analysis of the PMF ratio storms is a storm half the magnitude of the storm being analyzed. All of the inflow to the lake from the antecedent storms passes through the spillway and results in a starting elevation at the spillway crest for the analysis of the 23%, 50%, and 100% PMF.

The antecedent storm for the analysis of the 1% probability storm is the rainfall in the 24 hours preceding the peak 24-hour period assuming a 48-hour duration. The computer program is only able to model a 24-hour storm when the time interval is 5 minutes, as it was for this analysis. Therefore, for the analysis of Lake Adelle Dam, the antecedent rainfall was assumed to infiltrate and result in the AMC III used for the analysis of the peak 24 hours and the starting elevation of the lake was assumed to be 621.1.

The above methodology has been accomplished for this report using the systematized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site and input to the program are listed on Exhibit 7. Definitions of these variables are contained in the "User's Manual" for the computer program.

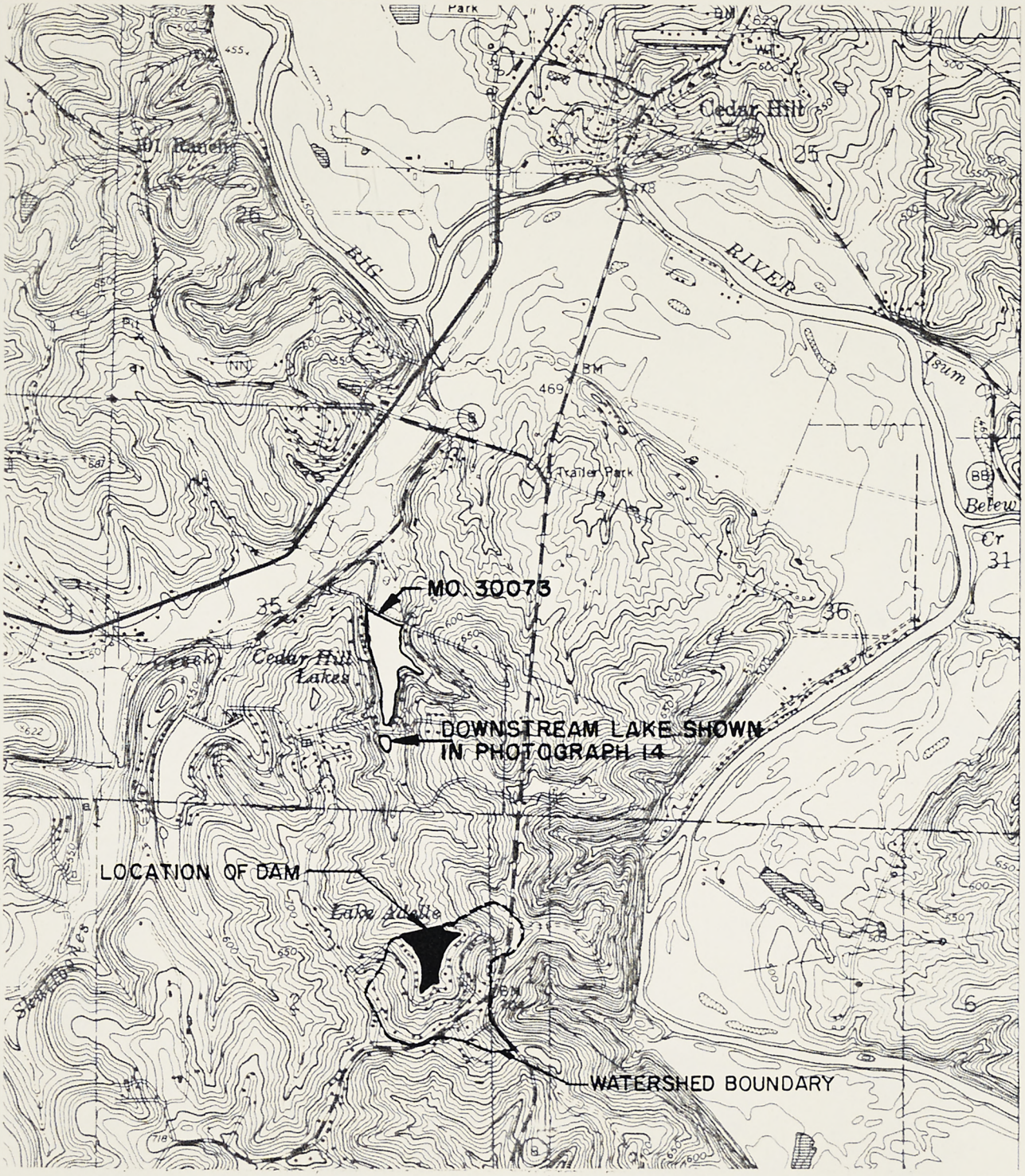
The computer printout of the inflow to the lake and outflow from the lake for the 23% PMF, 50% PMF and 100% PMF are presented on Exhibits 8, 9 and 10 respectively. The computer printout summary table for the overtopping analysis is presented on Exhibit 11.

C. REFERENCES:

a. Flood Hydrograph Package (HEC-1), Users Manual for Dam Safety Investigations, The Hydrologic Engineering Center, U. S. Army Corps of Engineers, Davis, California; September, 1978.

b. Riedel, J. T., Appleby, J. F., and Schloemer, R. W., Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24 and 48 Hours Hydrometeorological Report No. 33, U. S. Department of Commerce, Weather Bureau, April 1956.

c. Urban Hydrology for Small Watersheds, Technical Release No. 55, Engineering Division, Soil Conservation Service, U. S. Department of Agriculture, January, 1975.



CM&T	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	LAKE AND WATERSHED MAP LAKE ADELLE DAM MO. 30411

EXHIBIT 1

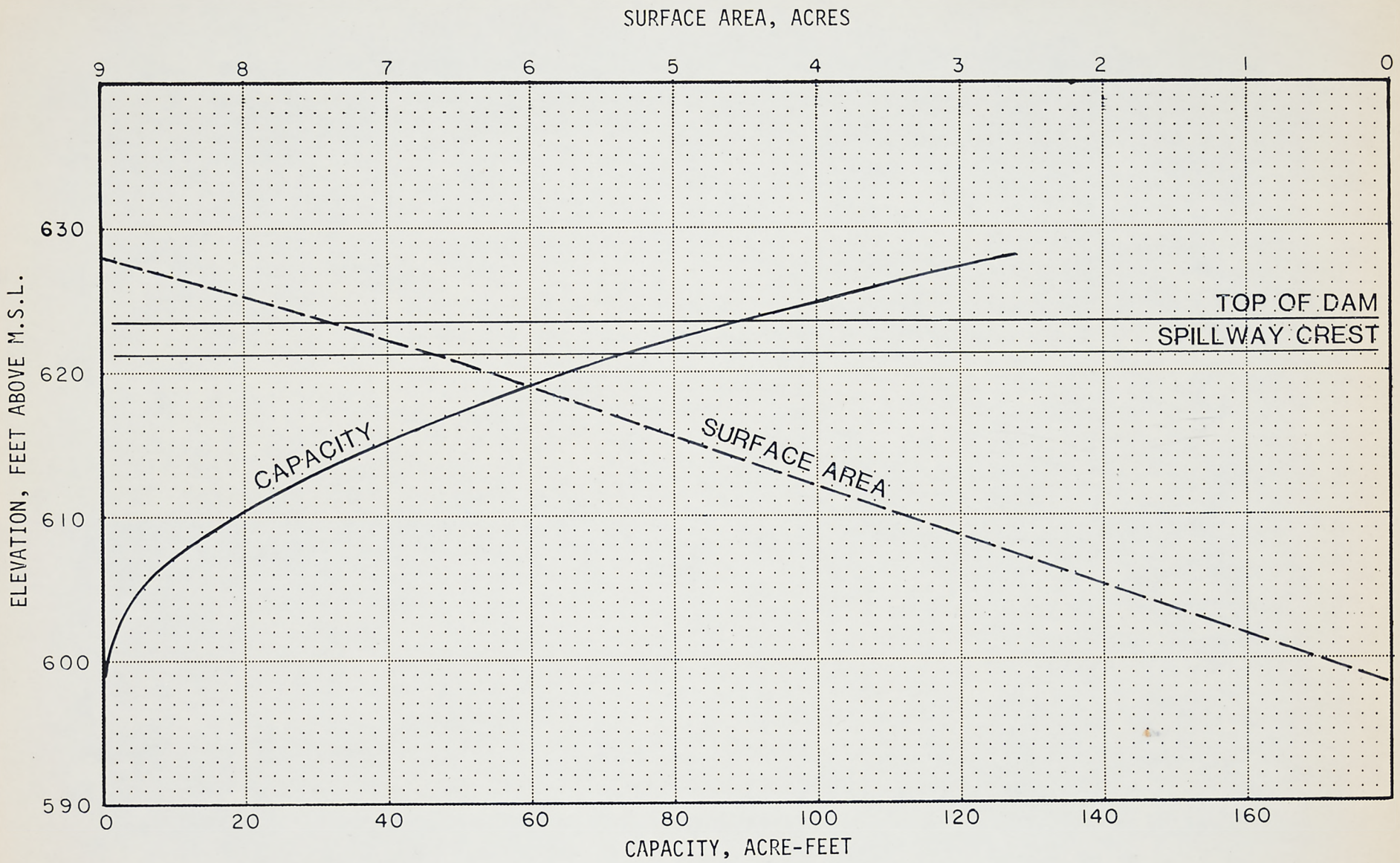


EXHIBIT 2

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers
SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

ELEVATION - AREA - CAPACITY RELATION
LAKE ADELLE DAM MO. 30411

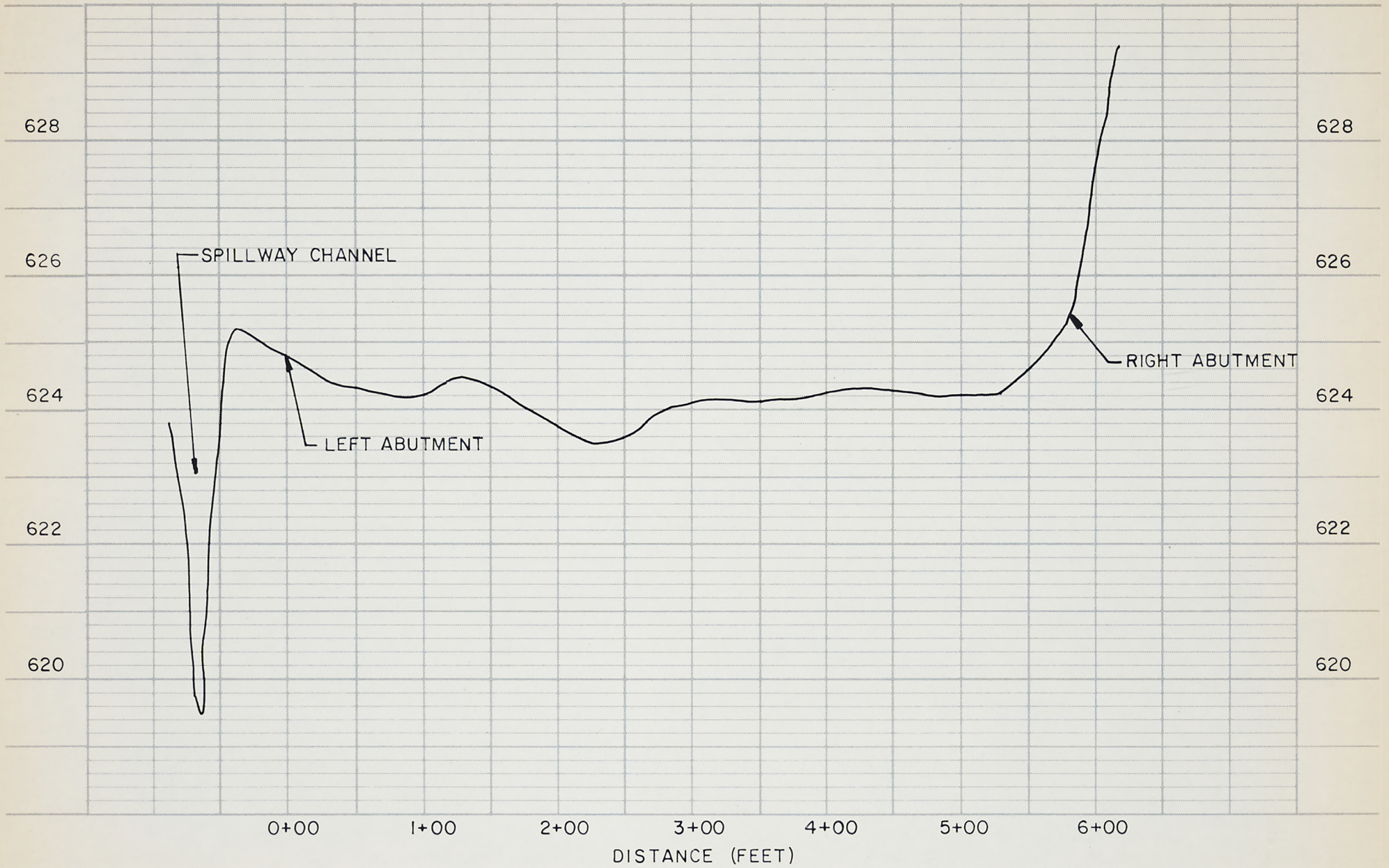


EXHIBIT 3

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	PROFILE OF DAM CREST LAKE ADELLE DAM MO. 30411

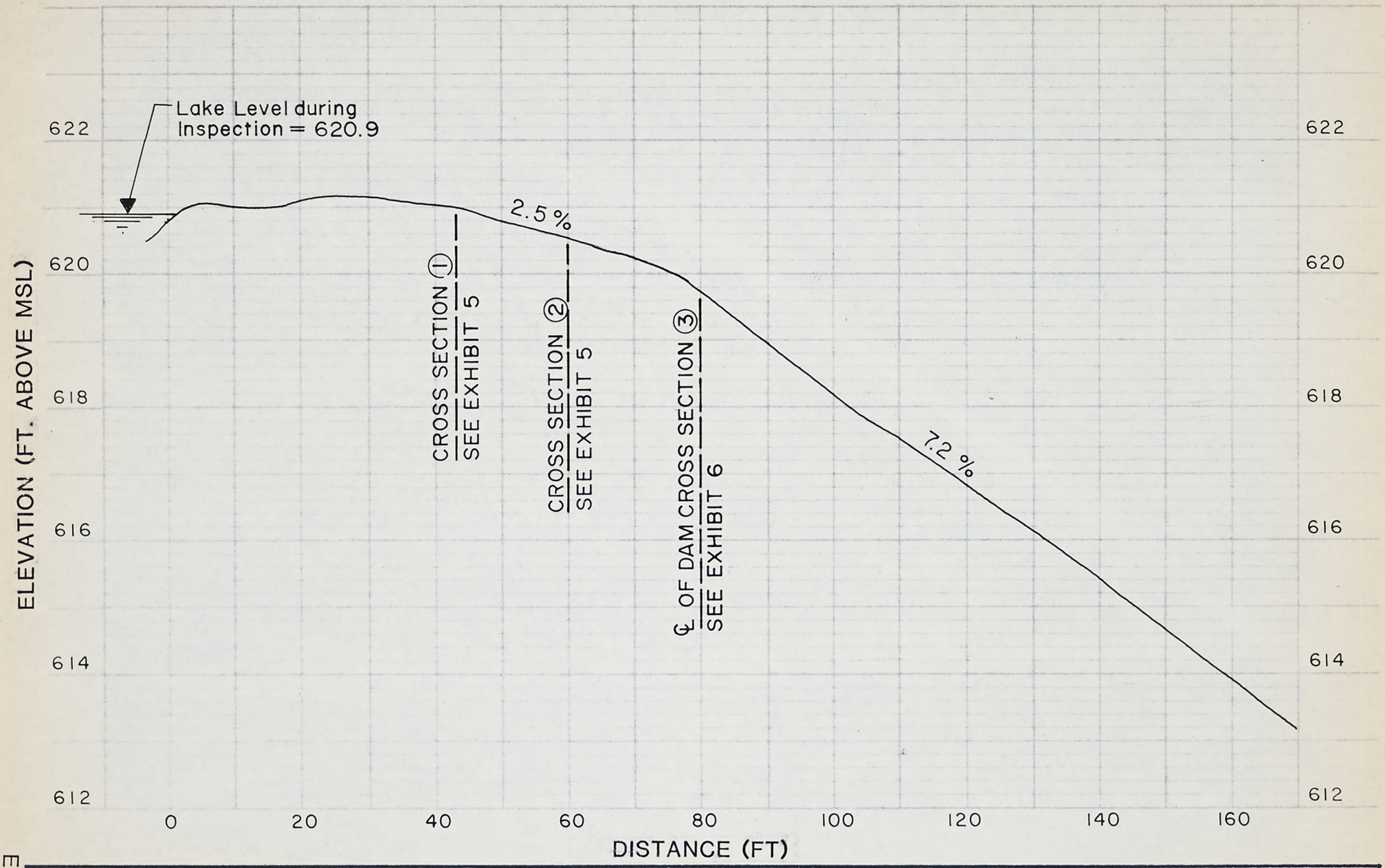
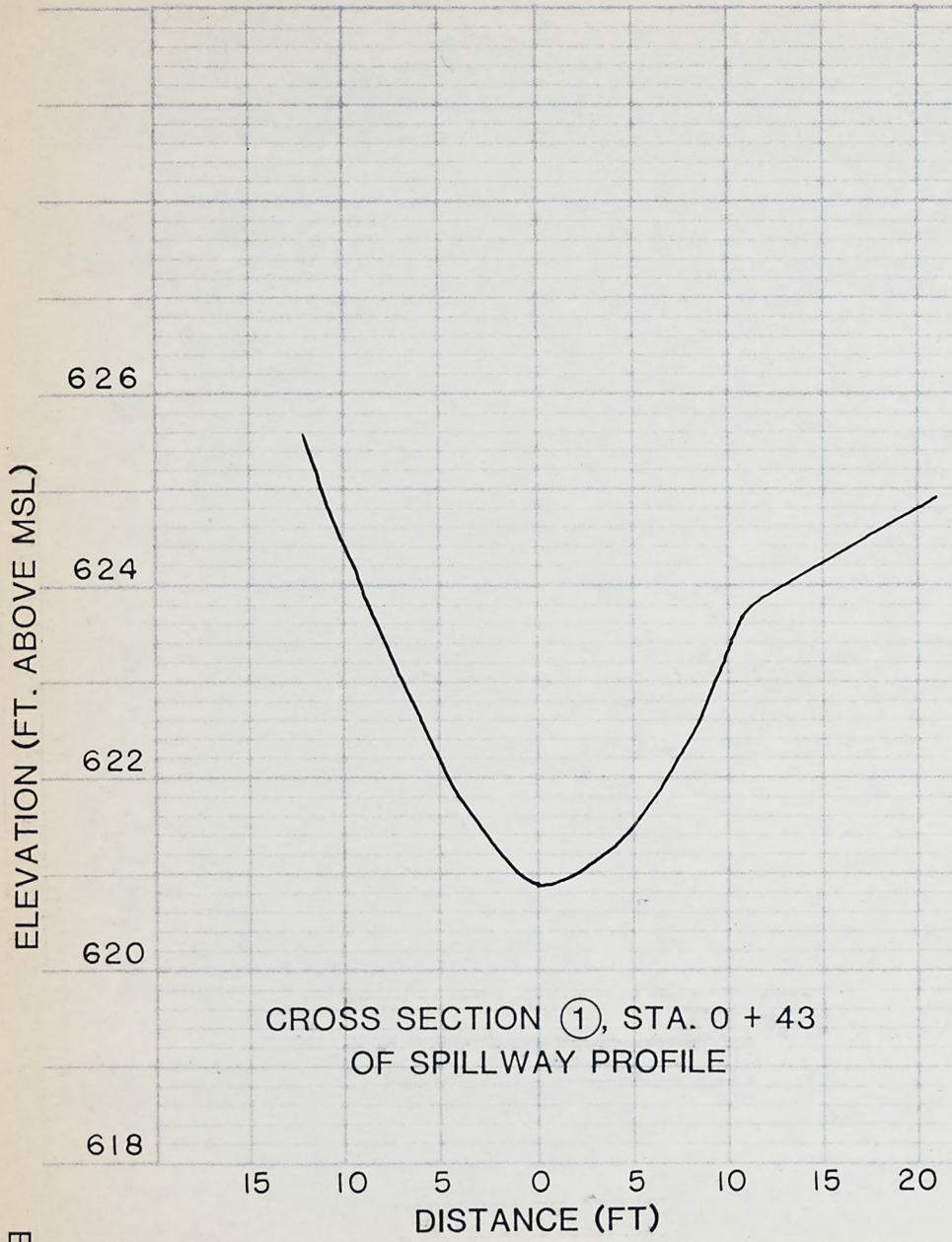
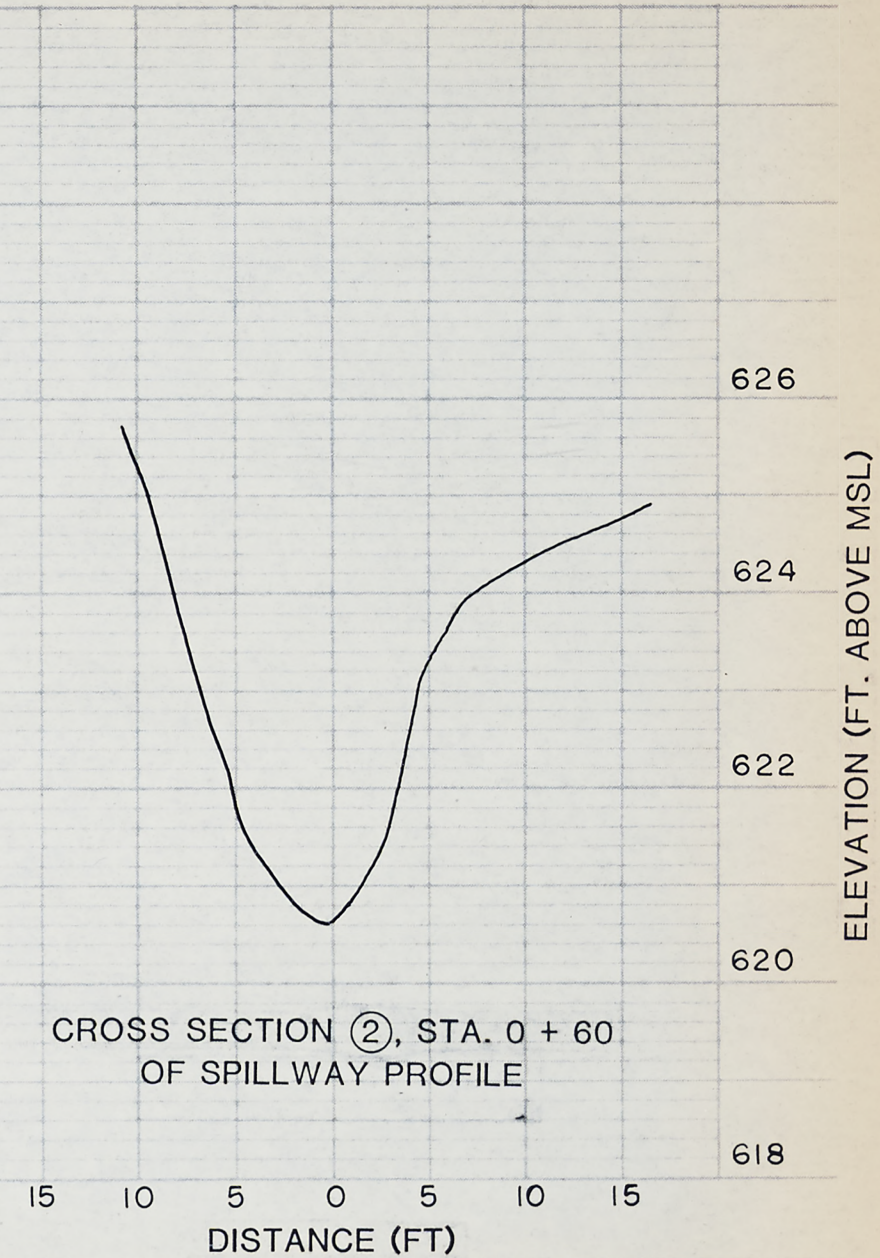


EXHIBIT 4

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	SPILLWAY FLOWLINE PROFILE LAKE ADELLE DAM MO30411



CROSS SECTION ①, STA. 0 + 43
OF SPILLWAY PROFILE



CROSS SECTION ②, STA. 0 + 60
OF SPILLWAY PROFILE

EXHIBIT 5

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	SPILLWAY CHANNEL CROSS SECTIONS LAKE ADELLE DAM MO30411

CROSS SECTION ③, CENTERLINE OF DAM
STA. 0 + 80 OF SPILLWAY PROFILE

EXHIBIT 6

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	SPILLWAY CHANNEL CROSS SECTIONS LAKE ADELLE DAM MO30411

```
A1 HYDROLOGIC/HYDRAULIC ANALYSIS -- LAKE ADELLE DAM(MO 30411), JEFFERSON CO.
A2 NATIONAL DAM SAFETY PROGRAM -- CORPS OF ENGINEERS, ST. LOUIS DISTRICT
A3 CM&T JOB NO. 8034-02       MARCH 20,1981
B    288       0       5       0       0       0       0       0      -2       0
B1     5
J      1       9       1
J1  0.10    0.12    0.15    0.20    0.23    0.24    0.25    0.50     1.0
K      0  INFLOW                                          1
K1 INFLOW HYDROGRAPH COMPUTATION
M      1       2   0.093                       1                       1
P      0    26.5     102     120     130
T                                                      -1     -91              0.12
W2          0.12
X      0     -.1    1.75
K      1    LAKE                                       1
K1 RESERVOIR ROUTING BY MODIFIED PULS METHOD
Y                                      1       1
Y1     1                                           -621.1      -1
Y4 621.1   621.5   622.0   622.5   623.0   623.5   624.0   624.5   625.0
Y5     0     2.4    12.5    32.0    62.5     101     156     238     340
$A     0     0.5     3.4     6.3     8.6
$E   598     600     610     620     627
$$ 621.1
$D 623.5     2.6     1.5     580
$L     0     100     250     420     525     575     590     600
$V 623.5   624.0   624.2   624.3   624.5   625.0   626.0   627.0
K     99
```

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 5

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	3.	6.	7.	8.	9.	9.	9.	9.
9.	9.	9.	9.	10.	10.	10.	10.	10.	10.
10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
10.	10.	10.	11.	11.	11.	11.	11.	11.	11.
11.	11.	11.	11.	11.	11.	11.	11.	11.	11.
11.	11.	11.	11.	11.	11.	11.	11.	11.	11.
11.	11.	11.	11.	16.	26.	32.	35.	36.	36.
37.	37.	37.	37.	37.	37.	38.	41.	43.	44.
44.	44.	44.	44.	44.	44.	44.	44.	47.	51.
54.	55.	55.	56.	56.	56.	56.	56.	56.	56.
52.	50.	57.	70.	89.	138.	248.	309.	248.	175.
128.	96.	77.	64.	57.	54.	53.	52.	52.	52.
52.	52.	52.	52.	50.	46.	43.	42.	41.	41.
41.	41.	41.	41.	41.	41.	34.	30.	28.	26.
25.	24.	22.	21.	20.	19.	18.	17.	16.	15.
14.	13.	13.	12.	11.	11.	10.	10.	9.	9.
8.	8.	7.	7.	7.	6.	6.	6.	5.	5.
5.	4.	4.	4.	4.	4.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	4.	4.		

STATION LAKE, PLAN 1, RATIO 5

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	3.	3.	3.	3.	3.	3.	3.	4.
4.	4.	4.	4.	4.	4.	5.	5.	5.	5.
5.	5.	5.	5.	5.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	7.	7.	8.	8.	9.
9.	10.	10.	11.	12.	12.	13.	14.	15.	16.
17.	18.	19.	20.	21.	22.	23.	23.	24.	25.
26.	27.	28.	29.	30.	31.	32.	33.	35.	36.
37.	38.	39.	40.	42.	46.	55.	69.	83.	92.
96.	97.	97.	95.	93.	90.	87.	85.	83.	81.
79.	77.	75.	74.	72.	70.	68.	67.	65.	63.
62.	61.	60.	58.	58.	57.	55.	54.	53.	51.
50.	48.	47.	45.	44.	43.	41.	40.	39.	37.
36.	35.	33.	32.	31.	31.	30.	29.	28.	28.
27.	26.	26.	25.	24.	23.	23.	22.	22.	21.
20.	20.	19.	19.	18.	17.	17.	16.	16.	16.
15.	15.	14.	14.	13.	13.	13.	12.	12.	12.
12.	12.	12.	11.	11.	11.	11.	11.	11.	11.
10.	10.	10.	10.	10.	10.	10.	10.		

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

INFLOW AND OUTFLOW
23% PMF
LAKE ADELLE DAM MO30411

EXHIBIT 8

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 8

0.	0.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
4.	4.	7.	12.	16.	18.	18.	19.	19.	20.
20.	20.	20.	21.	21.	21.	21.	21.	21.	21.
22.	22.	22.	22.	22.	22.	22.	22.	22.	22.
22.	22.	22.	22.	22.	23.	23.	23.	23.	23.
23.	23.	23.	23.	23.	23.	23.	23.	23.	23.
23.	23.	23.	23.	23.	23.	23.	23.	23.	23.
23.	23.	23.	23.	23.	23.	23.	23.	23.	23.
23.	23.	23.	23.	34.	56.	70.	75.	78.	79.
80.	80.	80.	80.	80.	80.	83.	90.	94.	95.
96.	96.	96.	97.	97.	97.	97.	97.	101.	111.
117.	119.	120.	121.	121.	121.	121.	121.	121.	121.
112.	108.	125.	152.	194.	300.	539.	672.	538.	380.
278.	209.	167.	139.	124.	117.	115.	114.	114.	113.
113.	113.	113.	113.	109.	99.	93.	91.	90.	89.
89.	89.	89.	89.	89.	89.	73.	64.	61.	57.
54.	51.	49.	46.	43.	41.	39.	37.	35.	33.
31.	29.	28.	26.	25.	23.	22.	21.	20.	19.
18.	17.	16.	15.	14.	13.	13.	12.	11.	11.
10.	10.	9.	9.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.		

STATION LAKE, PLAN 1, RATIO 8

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	2.
2.	2.	2.	2.	2.	2.	2.	3.	3.	3.
4.	4.	4.	5.	5.	6.	6.	6.	7.	7.
7.	7.	8.	8.	8.	9.	9.	9.	9.	10.
10.	10.	10.	11.	11.	11.	11.	12.	12.	12.
12.	13.	13.	13.	14.	14.	14.	15.	15.	15.
16.	16.	16.	16.	17.	17.	17.	17.	18.	18.
18.	18.	18.	19.	19.	20.	22.	24.	26.	28.
29.	31.	34.	36.	39.	41.	44.	46.	49.	51.
54.	56.	58.	61.	63.	65.	67.	69.	71.	74.
77.	80.	82.	85.	87.	90.	92.	94.	96.	97.
99.	99.	101.	104.	111.	128.	181.	342.	515.	474.
378.	305.	254.	218.	192.	176.	163.	154.	147.	141.
137.	134.	131.	128.	126.	123.	120.	117.	114.	111.
109.	107.	105.	104.	102.	101.	100.	98.	95.	93.
90.	88.	85.	83.	80.	77.	75.	72.	70.	67.
65.	62.	60.	58.	57.	55.	53.	51.	49.	48.
46.	44.	43.	41.	40.	38.	37.	35.	34.	33.
32.	31.	30.	29.	28.	28.	27.	26.	26.	25.
24.	24.	23.	22.	22.	21.	21.	20.	20.	19.
19.	19.	18.	18.	17.	17.	17.	16.	16.	16.
15.	15.	15.	15.	14.	14.	14.	14.		

CM&T	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	INFLOW AND OUTFLOW 50% PMF LAKE ADELLE DAM MO30411

EXHIBIT 9

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 9

0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	2.	2.	2.	2.	2.
3.	3.	3.	3.	3.	4.	4.	4.	4.	4.
4.	5.	5.	5.	5.	5.	5.	5.	5.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
7.	7.	7.	7.	8.	8.	8.	8.	8.	8.
8.	8.	13.	24.	32.	35.	37.	38.	39.	39.
40.	40.	41.	41.	41.	42.	42.	42.	43.	43.
43.	43.	43.	44.	44.	44.	44.	44.	44.	44.
45.	45.	45.	45.	45.	45.	45.	45.	45.	45.
45.	46.	46.	46.	46.	46.	46.	46.	46.	46.
46.	46.	46.	46.	46.	46.	46.	46.	46.	46.
46.	46.	46.	46.	47.	47.	47.	47.	47.	47.
47.	47.	47.	47.	69.	112.	140.	151.	156.	158.
159.	160.	160.	160.	160.	160.	167.	179.	187.	190.
192.	193.	193.	193.	193.	193.	193.	193.	203.	222.
233.	238.	241.	241.	242.	242.	242.	242.	242.	242.
224.	216.	250.	305.	387.	599.	1078.	1343.	1077.	760.
555.	418.	334.	278.	248.	235.	230.	228.	227.	227.
227.	227.	227.	227.	217.	199.	187.	182.	180.	179.
178.	178.	178.	178.	178.	178.	147.	128.	121.	115.
109.	103.	97.	92.	87.	82.	78.	73.	69.	66.
62.	59.	55.	52.	50.	47.	44.	42.	40.	37.
35.	34.	32.	30.	28.	27.	25.	24.	23.	21.
20.	19.	18.	17.	16.	16.	16.	16.	16.	16.
16.	16.	16.	16.	16.	16.	16.	16.	16.	16.
16.	16.	16.	16.	16.	16.	16.	16.	16.	16.
16.	16.	16.	16.	16.	16.	16.	16.		

STATION LAKE, PLAN 1, RATIO 9

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	3.	3.	4.	5.
5.	6.	7.	8.	8.	9.	10.	10.	11.	11.
12.	13.	14.	15.	16.	17.	18.	19.	20.	21.
22.	23.	24.	25.	25.	26.	27.	27.	28.	29.
29.	30.	31.	31.	32.	32.	33.	34.	34.	35.
36.	36.	37.	37.	38.	38.	39.	39.	40.	40.
40.	41.	41.	41.	42.	42.	42.	42.	43.	43.
43.	43.	44.	44.	45.	47.	52.	57.	62.	69.
75.	81.	87.	92.	97.	101.	107.	114.	123.	132.
141.	150.	158.	165.	170.	175.	178.	181.	185.	191.
200.	211.	219.	226.	231.	234.	237.	239.	240.	241.
238.	232.	232.	249.	290.	401.	736.	1177.	1209.	951.
687.	527.	420.	350.	305.	276.	258.	247.	241.	236.
233.	231.	230.	229.	227.	221.	213.	205.	199.	194.
191.	188.	186.	184.	183.	182.	178.	169.	160.	152.
145.	139.	133.	127.	122.	117.	113.	109.	105.	101.
99.	96.	93.	91.	88.	85.	83.	80.	77.	74.
72.	69.	67.	64.	62.	60.	58.	56.	54.	52.
51.	49.	47.	45.	44.	42.	41.	39.	38.	37.
36.	34.	33.	32.	32.	31.	30.	30.	29.	29.
28.	28.	27.	27.	27.	26.	26.	25.	25.	25.
24.	24.	24.	23.	23.	23.	23.	22.		

CM&T	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	INFLOW AND OUTFLOW 100% PMF LAKE ADELLE DAM MO30411

EXHIBIT 10

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .10	RATIO 2 .12	RATIO 3 .15	RATIO 4 .20	RATIO 5 .23	RATIO 6 .24	RATIO 7 .25	RATIO 8 .50	RATIO 9 1.00
HYDROGRAPH AT	INFLOW	.09	1	134.	161.	201.	269.	309.	322.	336.	672.	1343.
		(.24)		(3.80)(	4.56)(	5.70)(	7.61)(	8.75)(	9.13)(	9.51)(	19.01)(	38.03)
ROUTED TO	LAKE	.09	1	28.	38.	54.	81.	97.	103.	111.	515.	1209.
		(.24)		(.80)(	1.07)(	1.52)(	2.30)(	2.76)(	2.92)(	3.13)(	14.58)(	34.22)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	621.10	621.10	623.50
STORAGE	73.	73.	89.
OUTFLOW	0.	0.	101.

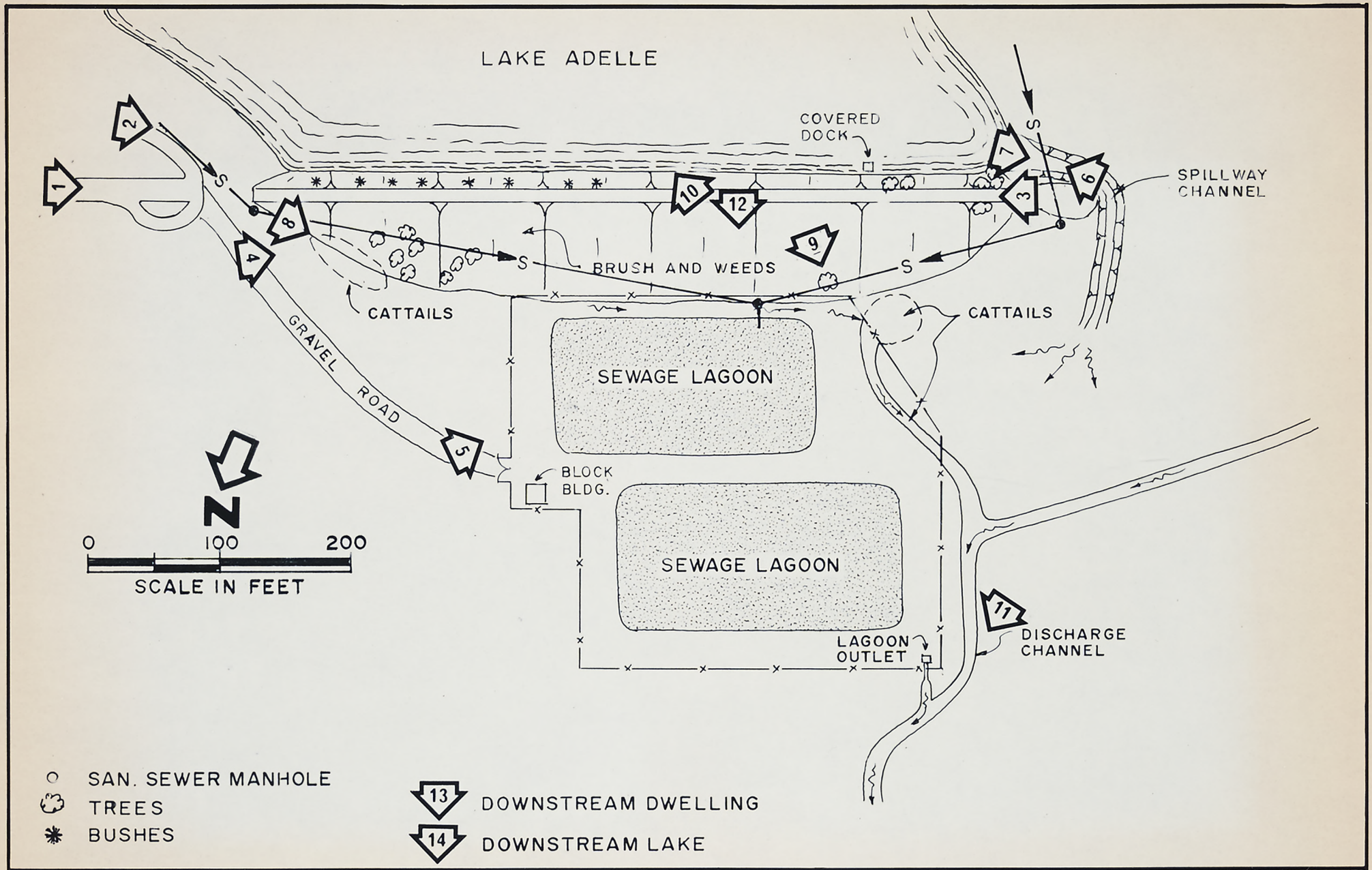
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	622.40	0.00	81.	28.	0.00	16.17	0.00
.12	622.60	0.00	83.	38.	0.00	16.08	0.00
.15	622.85	0.00	85.	54.	0.00	16.08	0.00
.20	623.24	0.00	87.	81.	0.00	16.00	0.00
.23	623.45	0.00	89.	97.	0.00	16.00	0.00
.24	623.52	.02	90.	103.	.25	16.00	0.00
.25	623.58	.08	90.	111.	.50	16.00	0.00
.50	624.42	.92	96.	515.	2.75	15.75	0.00
1.00	624.80	1.30	99.	1209.	6.17	15.75	0.00

EXHIBIT 11

PHASE I INSPECTION REPORT

APPENDIX C

PHOTOGRAPHS



CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers
SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

PHOTOGRAPH INDEX
LAKE ADELLE DAM MO. 30411

Photograph 2. Upstream face of dam viewed from the right abutment.

Photograph 3. Crest of dam viewed from the left abutment.

Photograph 4. Downstream face of dam viewed from the right abutment.

Photograph 5. Downstream face of dam and one cell of the sewage lagoon.

Photograph 6. Looking upstream at the spillway approach channel from the spillway crest.

Photograph 7. Looking downstream at spillway channel from approach channel.

Photograph 8. View of cattails at downstream right abutment.

Photograph 9. Cattails beyond the toe of the dam at the left abutment.

Photograph 10. View of lake and drainage area from the dam.

Photograph 11. View of discharge channel.

Photograph 12. View of sewage lagoons and downstream channel beyond them.

Photograph 13. View of dwelling located in the downstream hazard zone approximately 0.4 miles downstream of the dam. View is from the bank of the downstream channel.

Photograph 14. View of downstream lake located approximately 0.5 miles downstream of the dam.